REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

AD-A252 144

(2)

Report Date.	3. Report Type and Dates Covered.
1991	Contract

4. Title and Subtitle.
Modelling and Prediction of Regions of the North Pacific

5. Funding Numbers.
Program Element No. 0603207N
Project No. 0101
Task No. 1004
Accession No. DN256068

6. Author(s).
Alan R. Robinson*

7. Performing Organization Name(s) and Address(es).
*Harvard University
Division of Applied Sciences
Cambridge, Ma 02138

8. Performing Organization Report Number.
Final Technical Report

9. Sponsoring/Monitoring Agency Name(s) and Address(es).
Naval Oceanographic and Atmospheric Research Laboratory
Ocean Science Directorate
Stennis Space Center, MS 39529-5004

10. Sponsoring/Monitoring Agency Report Number.
CR 044:91

11. Supplementary Notes.
Contract N00014-87-K-6009

12a. Distribution/Availability Statement.
Approved for public release, distribution is unlimited.

12b. Distribution Code.

13. Abstract *(Maximum 200 words)*.
This was a project for the identification and description of the phenomenology and research into the development of a nowcast and forecast scheme for the frontal location and predominant features of the sub-arctic frontal region of the North Pacific Ocean. The potential coupling of the Harvard Open Ocean Model (HOOM) to a regional ocean model was investigated. The lead scientist at Harvard and Co-Principal Investigator was Dr. Richard Schmalz until March 1989, followed by Dr. Carlos Lozano. Mr. Wayne Leslie also participated. Professor Gunnar Roden of the University of Washington participated in the project as a principal scientist.

14. Subject Terms.
Ocean forecasting, ocean models, ocean dynamics

15. Number of Pages.
9

16. Price Code.

17. Security Classification of Report.	18. Security Classification of This Page.	19. Security Classification of Abstract.	20. Limitation of Abstract.
Unclassified	Unclassified	Unclassified	SAR

HARVARD UNIVERSITY

DIVISION OF APPLIED SCIENCES

PIERCE HALL
CAMBRIDGE, MASSACHUSETTS 02138
(617)–495–2819

ALLAN R. ROBINSON
Gordon McKay Professor
of Geophysical Fluid Dynamics

August 8, 1991

Dr. Donna W. Blake
Code N68462
NOARL
Code 323
Stennis Space Center
Mississippi 39529-5004

Dear Donna,

Enclosed please find the Final Technical Report on our ONR Contract Number N00014-87-K-6009, "Modelling and Prediction of Regions of the North Pacific" which was terminated October 1989.

Sincerely,

Allan R. Robinson
Principal Investigator

ARR:m

enclosure: (1) copy Final Technical Report

cc: (1) Ms. M. Sterns - OSR/Harvard
(1) Ms. Ruth Demone - DAS Accounting/Harvard
(1) Mr. R. Tanner - Administrative Contracting Officer
(1) Director - NRL
(20) NOARL

Final Technical Report

Modelling and Prediction of Regions of the North Pacific

NORDA Contract N00014-87-K-6009

1 July, 1987 — 1 October, 1989

Allan R. Robinson
Principal Investigator
Gordon McKay Professor of Geophysical Fluid Dynamics
Division of Applied Sciences
Harvard University

This was a project for the identification and description of the phenomenology and research into the development of a nowcast and forecast scheme for the frontal location and predominant features of the sub-arctic frontal region of the North Pacific Ocean. The potential coupling of the Harvard Open Ocean Model (HOOM) to a regional ocean model was investigated. The lead scientist at Harvard and Co-Principal Investigator was Dr. Richard Schmalz until March 1989, followed by Dr. Carlos Lozano. Mr. Wayne Leslie also participated. Professor Gunnar Roden of the University of Washington participated in the project as a principal scientist.

The identification and description of the phenomenology of the sub-arctic frontal region of the North Pacific Ocean was performed in two fashions: 1) the study of climatological and historical data (Roden and Robinson, 1988, 1989); and 2) the gathering of AXBT data sets which were repeated at one week intervals duri. g different seasons. Initially, data was collected at one week intervals for three weeks during February and April/May 1988. Intensive real-time exercises were conducted during June/July 1988 and June/July 1989. The data collected are described in various NOARL publications. Figure 1 describes the

typical frontal features of the region. The AXBT data gathered suggests the existence of a primary 300 km quarter-period wave with a 1 week quarter-period time scale. There is also evidence of a secondary wave superimposed on the primary wave. Additionally, the data suggests the existence of instabilities on the frontal wave structure.

Field data was objectively analyzed to provide model initialization and comparison fields for the development of al nowcast and forecast scheme. Analysis of the data for the statistical component of the procedure determined the utility of an isotropic correlation function with a zero crossing at 70 km and an e-folding scale equal to 40 km. There was insufficient data to determine the temporal correlation scale. Research into the problems of model initialization (extension of shallow AXBT data into deep fields, use of climatological $S(Z)$ with observed $T(Z)$ to provide dynamic height fields, level of no motion determination through barotropic mode adjustment) was accomplished using this analyzed field data. Initial results indicated that adequate results could be obtained through the use of a forecast model involving: nine levels, a flat bottom, a level of no motion at 1500 m, 15 km horizontal resolution, and 3 hour time steps. These forecast parameters were determined through the use of prototype hindcasts; varying model parameters and comparing model results (hindcasts) with analyzed data. Typical results for the 1988 forecast experiment data are shown on Figure 2. Four independent synoptic realizations providing initialization, updating and verification data for three forecast periods are shown on Fig. 2a. Figures 2b,c,d are forecasts and hindcasts using various strategies of persisting or interpolating boundary conditions around the rim of the domains, for the three forecast intervals.

Real-time field trials of the forecast system were accomplished in June/July 1988 and June/July 1989. The field trials tested the electronic data transfer methods and the ability of the forecast system to predict feature evolution in an operational mode. Forecasts were available within a few hours of receipt of the full initialization data. These forecasts used

persisted boundary conditions. As boundary updates were received from the field, new forecasts were performed using the improved boundary conditions. Subsequent full field data flights provided verification data for the forecasts and new initialization fields for al new set of forecasts. These trials were followed by post-analysis of the correspondence between forecasted and observed fields. Evaluation of the results showed that the connected model set forecasts predicted general feature propagation and form evolution in agreement with observed data and that an unusual observed instability was formed by the forecast system. It was determined that during the real-time forecast trials, satellite IR was of relatively little use due to significant cloud coverage.

Funding for this contract was ended before the scheduled finishing date of this project. As a result, research and development was left incomplete and conclusions could not be reached about many aspects of the unfinished work. The use of GEOSAT data as an aid to model initialization was inconclusive. The coupling of the HOOM to the Harvard Surface Boundary Layer Model for this region was in progress and the coupling of the HOOM to the NOARL regional model was in its initial stages.

The abrupt termination of this project precluded the accomplishment of the usual number of publications. One technical report was published, (Roden and Robinson, 1988). A second technical report (Roden and Robinson, 1989) was nearly completed and a non-final but technically useful draft is appended to this report.

Reports

Roden, G.I., and A.R. Robinson (1988), Subarctic Frontal Zone in the North-Eastern Pacific: Mesoscale Structure and Synoptic Description, Harvard Open Ocean Model Reports *31*, Reports in Meteorology and Oceanography, Harvard University.

Roden, G.I., and A.R. Robinson (1989), Subarctic-Subtropical Transition Zone in the North-Eastern Pacific: Mesoscale Structure and Synoptic Description, Harvard Open Ocean Model Report, Reports in Meteorology and Oceanography, Harvard University (UNPUBLISHED DRAFT).

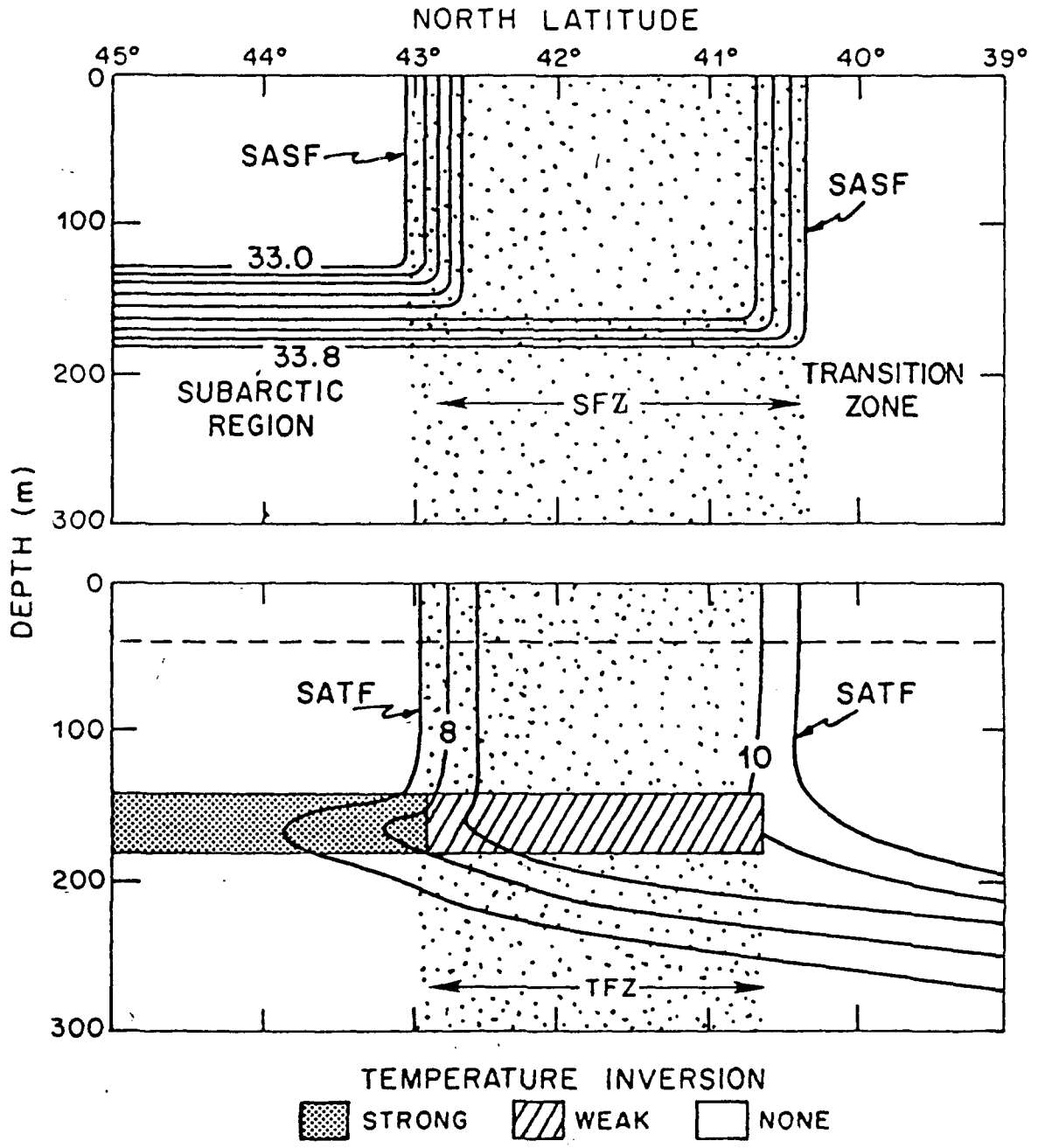


Figure 1 Schematic showing the subarctic temperature fronts (SATF), the subarctic salinity fronts (SASF), the subarctic temperature frontal zone (TFZ) stipled and the subarctic salinity frontal zone (SFZ). The frontal zones separate the subarctic region and the subarctic-subtropical transition zone.

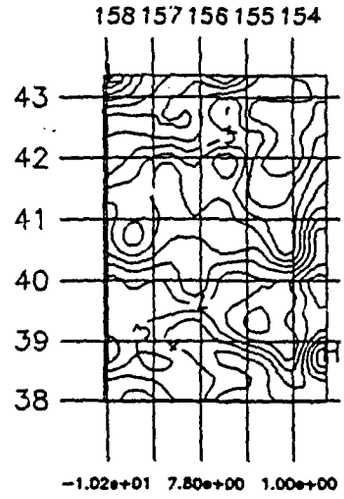
(Robinson and Roden, 1988 - Figure 4)

HARVARD UNIVERSITY NEPCAST

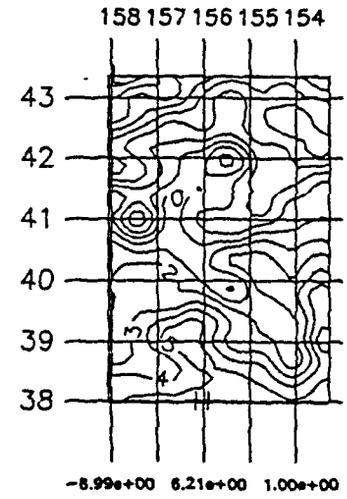
NEPAC - Initial and Boundary Condition Data

1500m Level of No Motion

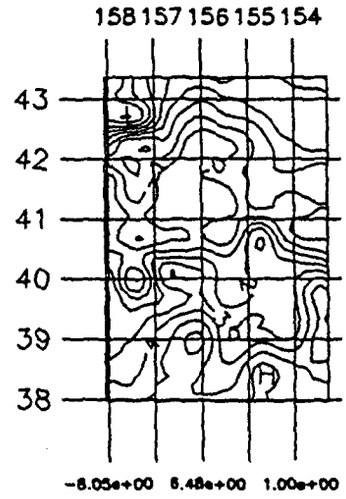
50. M Streamfunction



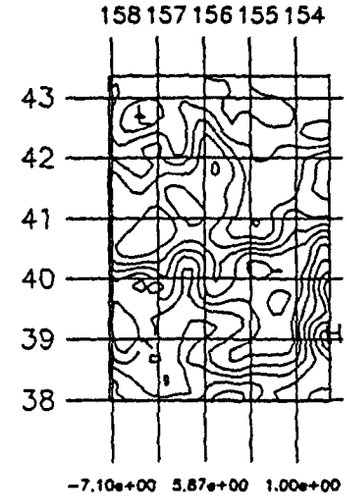
14 Jun 1988



25 Jun 1988



10 Jul 1988



20 Jul 1988

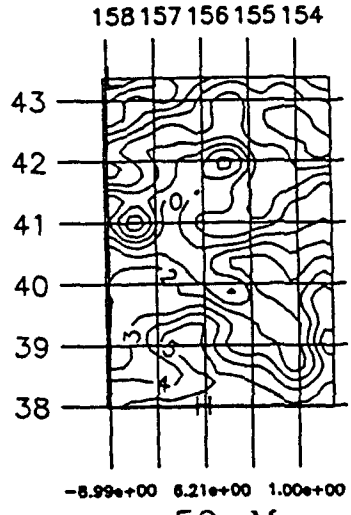
Figure 2a

Harvard University Nepcast

FORECAST COMPARISONS 15–25 JUNE

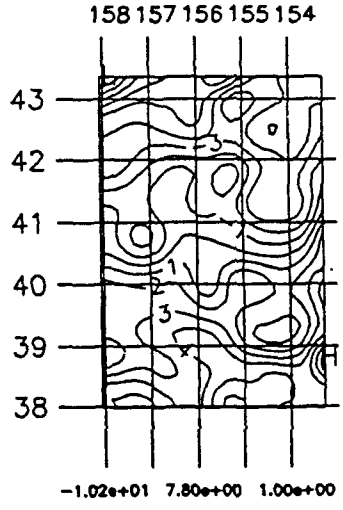
ard University
NEPCAST

1500m Level of No Motion
Streamfunction on 25 Jun 1988



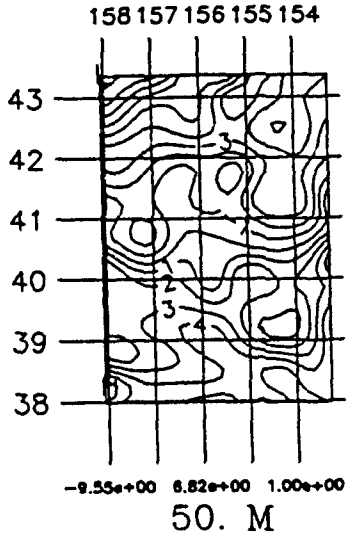
50. M

ɔjectively Analyzed Data



50. M

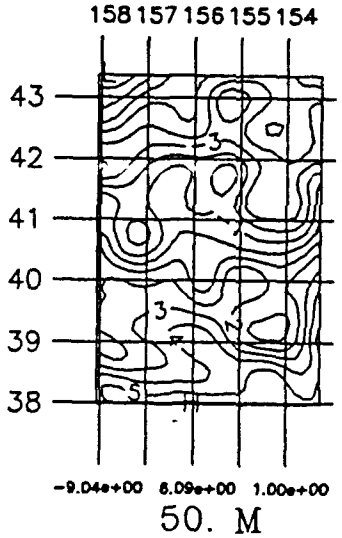
Persistence Forecast



50. M

terp/Persisted Forecast

June 21



50. M

Interpolated Forecast

June 21 and 25

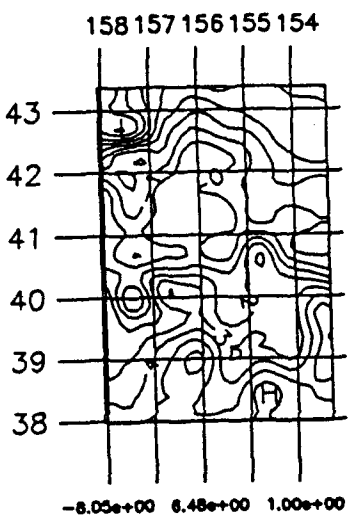
Figure 2b

Harvard University Nepcast

FORECAST COMPARISONS 26 JUNE – 10 JULY

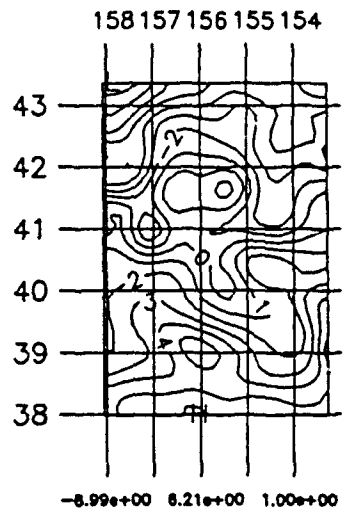
ard University
NEPCAST

1500m Level of No Motion
Streamfunction on 10 Jul 1988



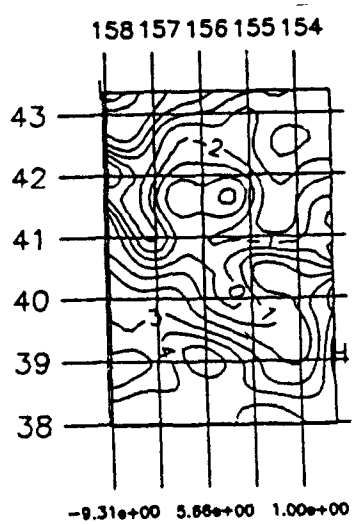
50. M

bjectively Analyzed Data



50. M

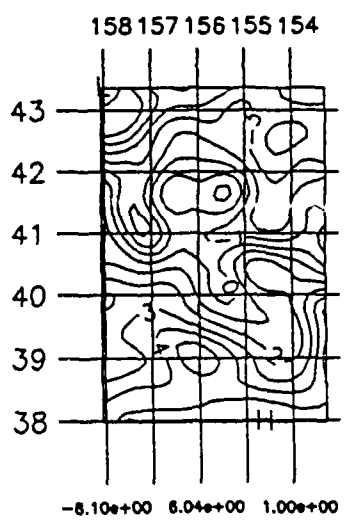
Persistence Forecast



50. M

nterp/Persisted Forecast

July 1



50. M

Interpolated Forecast

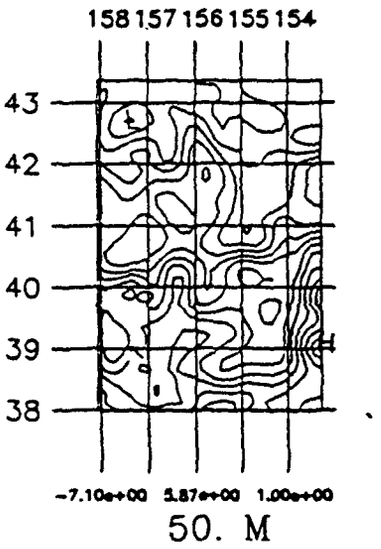
July 1 and 10

Figure 2c

Harvard University Nepcast

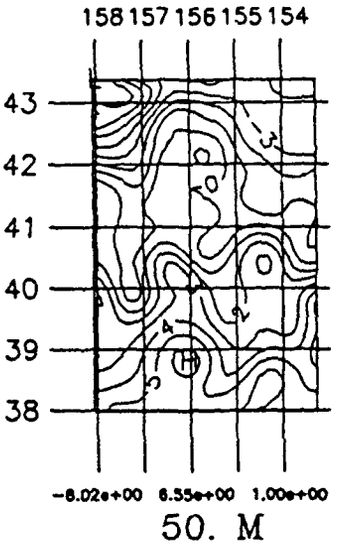
FORECAST COMPARISONS 10–20 JULY

1500m Level of No Motion
Streamfunction on 20 Jul 1988



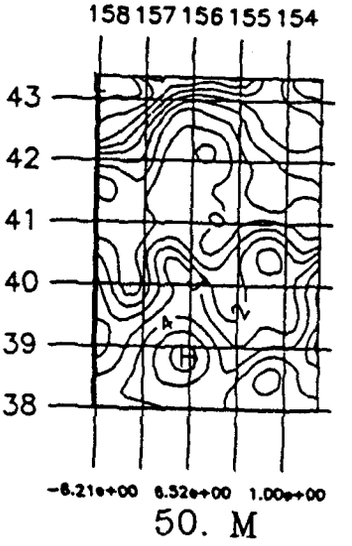
50. M

bjectively Analyzed Data



50. M

Persistence Forecast



50. M

Interpolated Forecast

July 20 and 24

Figure 2d